UNIVERSITY OF SASKATCHEWAN

College of Engineering

Department of Physics and Engineering Physics

E.P. 155.3

Electric and Magnetic Circuits I

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FINAL EXAMINATION

April 12, 2004

9:00 AM - 12:00 Noon

Indicate the E.P. 155.3 Lecture Section that you are registered in.

- ☐ Section 02 (T-Th 1:00-2:30) Education Gym
- ☐ Section 04 (T-Th 2:30-4:00) PAC Gym

STUDENT NAME: _____

STUDENT NUMBER: _____

Question 1	/ 10
Question 2	/ 10
Question 3	/ 9
Question 4	/ 10
Question 5	/ 7

Question 6	/ 6
Question 7	/ 10
Question 8	/ 7
Question 9	/ 6

TOTAL	/ 75

GENERAL INSTRUCTIONS FOR THE QUESTIONS

1) **Please place your answers in the boxes provided. Show units in all answers.**
2) Calculator allowed. One page (8½ x 11) of formulas allowed.
3) Please ensure that your name and student number are entered on every page.
4) Neatness counts. Please ensure your paper is readable. Please show your work.
5) Some questions contain special instructions. Please ensure that you read these carefully.
6) Not all questions are of the same difficulty and value. Please consider this when allocating time for the solution.
7) IF A QUESTION PROVES TO BE TOO HARD FOR YOU TO SOLVE, GO ON TO ANOTHER QUESTION! RETURN TO THE TROUBLESOME QUESTION WHEN TIME PERMITS.

Physical Constants

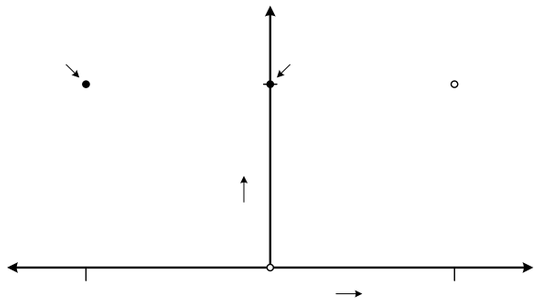
Constant	Symbol	Value	Units
Coulomb's law constant	k	9.0×10^{9}	Nm^2/C^2
Permittivity of free space	ε_0	8.854×10^{-12}	farad/m
Relative permittivity of Tantalum Oxide	ε_r	25	
Breakdown voltage of Tantalum Oxide		400	volts/μm
Breakdown voltage of Air		3	volts/μm
Permeability of free space	μ_0	$4\pi \times 10^{-7}$	H/m
Relative permeability of cast steel	μ_r	796	

Please check that your examination paper contains 15 pages TOTAL.

QUESTION #1

MARKS: 10 (4 + 4 + 2)

a) Point charges Q_1 (3 μC) and Q_2 (1 μC) are located at (0, 7) and (-7, 7) respectively, as shown below. Notice that the units of the X and Y axes are centimeters. Point A and point B are at locations (7, 7) and (0, 0) as shown in the figure below.



I. What is the force on a test charge of -5 μC placed at point B? Give the X and Y components (i.e., F_X and F_Y). Note: A positive answer for F_X means the force is to the right and a positive answer for F_Y means the force is upward.

II. Without the test charge at point B, what is V_{AB}?

b) A copper wire is lying near the terminals of a 12 volt car battery as shown in the figure below. The net charge in the wire is 0.

I. Why is there a force on the wire (explain in 2 or 3 sentences in the box provided)?

a I) Force on -5μC at point B? (4 marks)

F_X:

F_Y:

a II) Voltage V_{AB}? (4 marks)

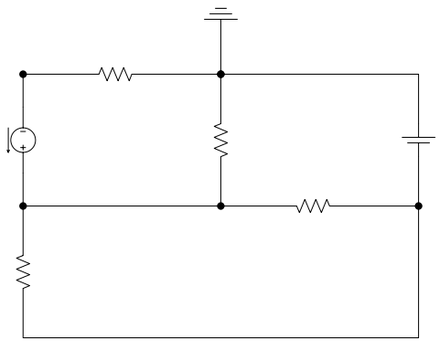
b I) Why is there a force on the wire? (2 marks)

Name: _____ **Student Number:** _____

QUESTION #2

MARKS: 10 (2 + 2 + 2 + 2 + 2)

Find the answers to the questions below by applying the superposition principle to the circuit shown. To receive marks for this question it must be solved by applying the superposition principle. Other solution methods are unacceptable.



a) What is the current through the 2Ω resistor due to the current source (give direction)?
b) What is the current through the 2Ω resistor due to the voltage source (give direction)?
c) What is the power dissipated by the 2Ω resistor?
d) What is the voltage V_{ab}?
e) How much energy is dissipated by 1C of charge as it moves through R_1?

a) $I_{2\Omega}$ (due to current source)? (2 marks)

Value?

Direction? (circle one): ↑ Up ↓ Down

b) $I_{2\Omega}$ (due to voltage source)? (2 marks)

Value?

Direction? (circle one): ↑ Up ↓ Down

c) Power dissipated by 2Ω (total)? (2 marks)

d) Voltage V_{ab}? (2 marks)

e) Energy dissipated by 1C of charge as it moves through R_1? (2 marks)

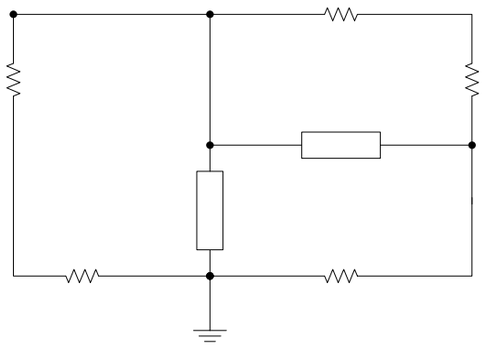
Name: _____ **Student Number:** _____

QUESTION #3

MARKS: 9 (1 + 1 + 2 + 1 + 1 + 1 + 1 + 1)

The circuit shown below has two unknown components, **X** and **Y**. It is known that one of these is an ideal battery and the other one is a resistor. The current through resistor R_1 is 0.5A. The polarity of the voltage across resistor R_1 is as indicated. The voltage at point **b** is -3V.

Supply the information required in the boxes provided.



USE THE NEXT PAGE AS A CALCULATION PAGE FOR THIS QUESTION.

a

R

a) Voltage at point a? (1 mark)

b) Magnitude of current through R_5? (1 mark)

c) Is component Y a resistor or a battery? Explain. (2 marks)

e) Is component X a resistor or a battery? (1 mark)

f) What is the value of component X? (1 mark)

g) Magnitude of current through component X? (1 mark)

d) What is the value of component Y? (1 mark)

h) Voltage V_{ab}? (1 mark)

Name: _____ **Student Number:** _____

QUESTION #3 Work Sheet

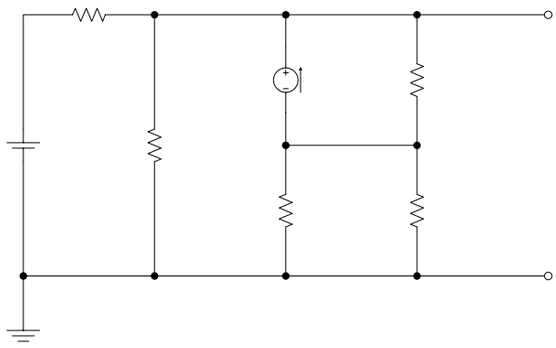
Name: _____ Student Number: _____

QUESTION #4

MARKS: 10 (6 + 2 + 2)

Consider the circuit shown below.

a) Determine the Thévenin equivalent circuit for terminals a-b. Draw your resulting circuit and indicate polarity.
b) Based upon your answer in part a), what is the Norton equivalent circuit for terminals a-b?
c) What value of resistance must be used as the load on terminals a-b for maximum power transfer?



USE THE NEXT PAGE AS A CALCULATION PAGE FOR THIS QUESTION.

a) E_{TH}? (4 marks)

R_{TH}? (2 marks)

b) I_N? (1 mark)

R_N? (1 mark)

c) R_L for maximum power transfer? (2 marks)

Name: _____ **Student Number:** _____

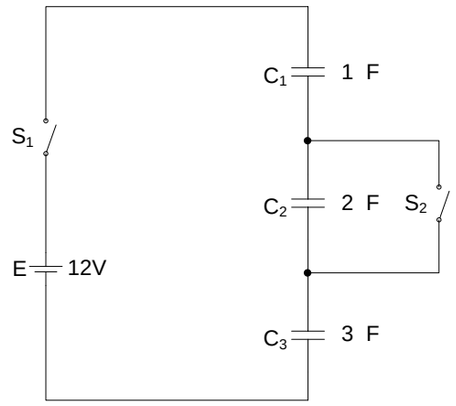
QUESTION #4 Work Sheet

Name: _____ Student Number: _____

QUESTION #5

MARKS: 7 (4 + 3)

Consider the circuit shown below. All switches are initially open and all capacitors are initially uncharged.



a) **S_1 is closed (S_2 is still open).**

I. Determine the equivalent capacitance as seen by the battery.
II. Determine the voltage across each capacitor.

b) **S_2 is now closed (S_1 is still closed).**

I. Determine the charge on each capacitor.

USE THE NEXT PAGE AS A CALCULATION PAGE FOR THIS QUESTION.

S_1 closed (S_2 still open)	**S_2 closed (S_1 still closed)**
a I) Equivalent capacitance? (1 mark)	**b I) Charge on C_1? (1 mark)**
a II) Voltage across C_1? (1 mark)	**Charge on C_2? (1 mark)**
Voltage across C_2? (1 mark)	**Charge on C_3? (1 mark)**
Voltage across C_3? (1 mark)	

Name: _____ **Student Number:** _____

QUESTION #5 Work Sheet

Name: _____ Student Number: _____

QUESTION #6

MARKS: 6 (2 + 4)

Tantalum oxide is to be used as a dielectric in the design of a parallel plate capacitor.

a) What is the minimum area of the capacitor such that it will have a capacitance of 70nF and be able to withstand a maximum voltage of 2kV across its parallel plates?
b) The dielectric is removed from the capacitor as designed in part a) leaving air between the parallel plates.
   I. What is the capacitance of the new parallel plate capacitor?
   II. Will the new capacitor still be able to withstand a maximum voltage of 2kV across its parallel plates?

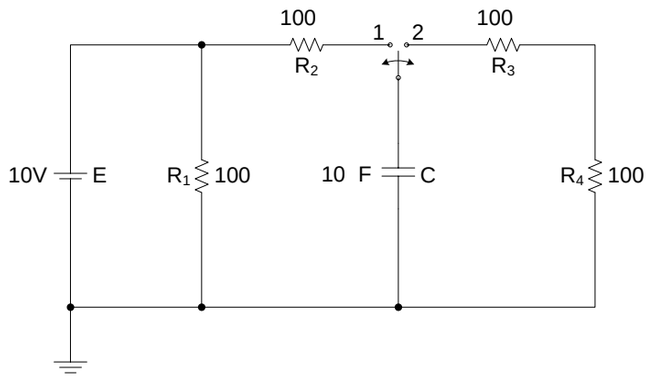
a) Minimum Area? (2 marks)	b I) Capacitance of new capacitor? (2 marks) b II)Will it still withstand 2kV? (2 marks) NO YES

Name: _____ **Student Number:** _____

QUESTION #7

MARKS: 10 (4 + 4 + 2)

Consider the circuit shown below. The switch is initially open (i.e., placed in the center position) and the capacitor is initially uncharged.



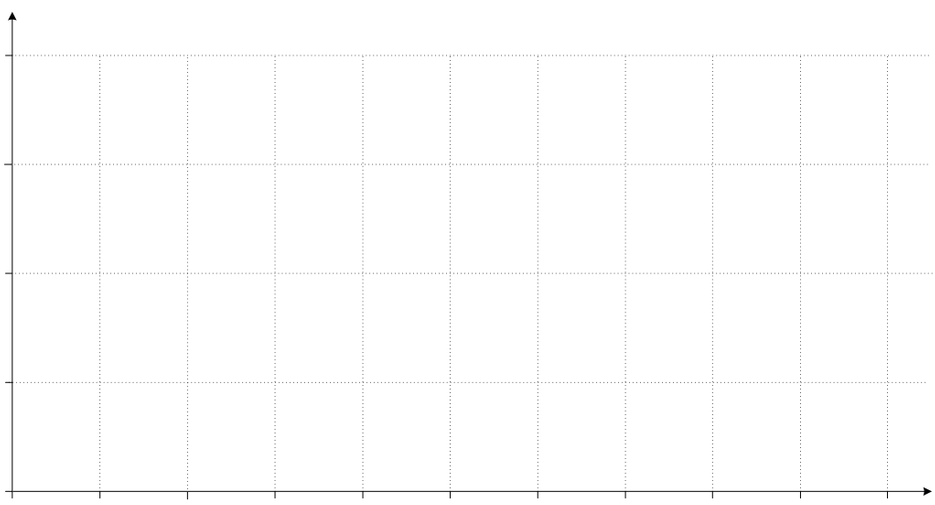
a) The switch is moved to position 1.
   I. At what time does the voltage across the capacitor, v_c, reach 50% of its final value (value at t=∞)?
   II. What is the value of the voltage across the capacitor, v_c, at this time?

b) After the time required in part a) is reached, the switch is immediately moved to position 2 for 2 ms and then it is opened (i.e., placed in the center position).
   I. What is the value of the new final voltage across the capacitor, v_c?
   II. What is the value of the energy stored by the capacitor after the switch is opened?

c) Draw a sketch (using the template given below) of the capacitor voltage as a function of time. While the sketch does not have to be to scale, indicate all important times and capacitor voltage values.

USE THE NEXT PAGE AS A CALCULATION PAGE FOR THIS QUESTION.

Switch in position 1	**Switch in position 2 for 2ms, then opened**
a I) Time to 50% of final value? (2 marks)	**b I) Value of the new final capacitor voltage, v_c? (2 marks)**
a II) Value of capacitor voltage, v_c? (2 marks)	**b II) Energy stored by the capacitor? (2 marks)**



Name: _____ **Student Number:** _____

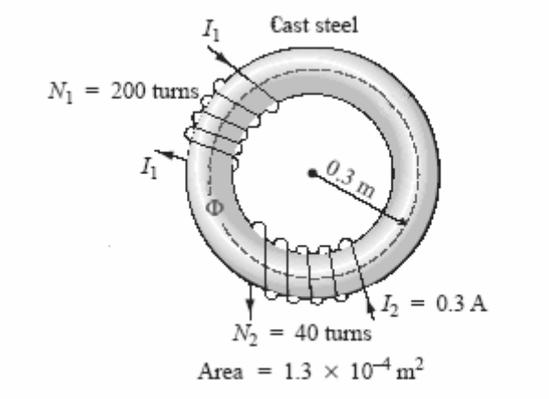
QUESTION #7 Work Sheet

Name: _____ Student Number: _____

QUESTION #8

MARKS: 7 (2 + 5)

Consider the cast steel toroid shown below. The toroid has a radius of 0.3m and a circular cross-sectional area of $1.3 \times 10^{-4} m^2$.



a) What is the direction of the flux, Φ, due to the current I_2?

b) What is the current, I_1, needed to create a total flux of 2.0×10^{-4} Wb clockwise?

a) Flux direction due to I_2 (circle one)? (2 marks)	b) Value of I_1? (5 marks)
↻ CLOCKWISE COUNTER-CLOCKWISE ↺	

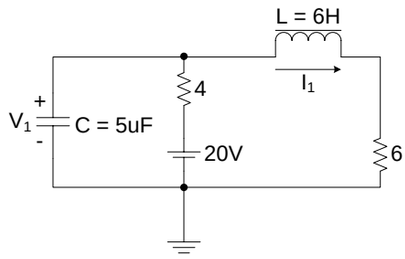
Name: _____ **Student Number:** _____

QUESTION #9

MARKS: 6 (4 + 2)

This question was Problem 5) on Assignment #11 (from Boylestad 3rd Canadian Edition, Problem 36, page 375). It is duplicated here as given in the Boylestad textbook.

a) Find the current I_1 and the voltage V_1 for the circuit shown.



b) Repeat part a) but replace the voltage source with a 24 V source.

a) I_1 (with 20 V source)? (2 marks)	b) I_1 (with 24 V source)? (1 mark)
V_1 (with 20 V source)? (2 marks)	V_1 (with 24 V source)? (1 mark)

Name: _____ **Student Number:** _____

Extra Work Sheet

Name: _____ Student Number: _____